Navigation-based In Vivo Knee Kinematics Of The New Gradually Reducing Radii Design Total Knee Arthroplasty

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Introduction: To date, various concepts and designs of total knee arthroplasty (TKA) prostheses have been developed for improvement in range of knee motion and other clinical outcomes. Numbers of factors are supposed to be contributing to kinematics of the TKA, including component types and conformity between femoral components and tibial inserts. The fluoroscopic evaluations of the TKA kinematics in the cruciate-retaining (CR) knees showed paradoxical anterior sliding movement of the femur on the medial side. Clary et al. (Journal of Biomechanics 2013) reported that in their simulation studies the paradoxical anterior femoral slide in a traditional dual radius TKA (PFC-sigma CR knee system, DePuy, Warsaw, IN) is initiated by the sudden reduction of the femoral radii from the distal to posterior. The new TKA design with gradually reducing femoral radii (Attune CR knee system, DePuy, Warsaw, IN) minimized the paradoxical anterior slide. It was hypothesized that similar results can be obtained in our study of navigation-based in vivo knee kinematics. The purpose of this study was to compare the kinematics of the new gradually reducing radii design TKA with the traditional dual radius design TKA in navigation-based in vivo simulation.

Methods: Studies were carried out on 12 osteoarthritis Knees using the CT-free navigation system (Kolibri Knee, Brain LAB). All patients were female with mean age of 75 years. Six knees were implanted with the PFC-sigma CR knee system and remaining 6 knees were implanted with the Attune CR knee system by navigated measured resection technique. Intra-operative knee kinematics during passive range of motion from full extension to 130 degrees of knee flexion was measured after implantation while patella reduced and tourniquet released. While supporting the foot with one hand, the surgeon used his opposite hand to gently lift the thigh, flexing the hip and knee. Two TKA systems were compared for following factors: Anterior-posterior (AP) displacement of the medial and lateral femoral condyles relative to tibia and the kinematic patterns of the femur throughout the range of motion.

Results: In the result of average AP displacement of the PFC-sigma CR, both condyles showed paradoxical anterior movement from 40 to 70 degrees of knee flexion (Fig.1). In the results of average kinematic pattern, both condyles moved in same manner, showing the parallel motion pattern. On the other hand, average AP displacement of the Attune CR showed no paradoxical anterior movement of both condyles (Fig.2). The average kinematic pattern of the Attune CR demonstrated medial pivot pattern from extension to 90 degrees of knee flexion. After that both condyle showed rollback to 130 degrees of knee flexion.

Discussion: A comparison of AP displacement between the PFC-sigma CR and the Attune CR showed similar results to Clary’s report. In their cadaver study and also in our navigation study, the PFC-sigma CR showed paradoxical anterior movement in mid-flexion. In contrast, the Attune CR showed stable motion with no paradoxical anterior sliding movements (Fig.3). In a comparison of kinematic pattern, the PFC-sigma showed parallel condyle motion pattern, the Attune showed medial pivot pattern. Distinctive
difference in kinematic characteristic for these two TKA designs were observed. As both TKAs were implanted using the same surgical technique, the results can be attributable to the changes in femoral radii design.

**Significance:** The TKA design with gradually reducing femoral radii minimized the paradoxical anterior slide in navigation-based in vivo knee kinematics study.

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**Fig. 1:** Average AP displacement of the PFC-Σ CR type \((n=6)\)

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**Fig. 2:** Average AP displacement of the Attune CR type \((n=6)\)
Fig. 3: A comparison of AP displacement between PFC and Attune